

Role of magnetopneumography measurement for prevention of pneumoconiosis

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1 Introduction

It is estimated that 400,000 people in Japan are currently working in environments with serious particle contamination [1]. The particles, including Fe_3O_4 , may be inhaled from work or urban environments, and cause pneumoconiosis. Accordingly, Japan has established particle control laws and strictly regulates work environments. Despite this, the incidence of lung disease due to particles is exhibiting no decreasing trend, and in recent years new cases have been regularly appearing.

The reason that the contamination of new individuals cannot be prevented is that there are no methods for measuring the quantities of particles accumulated in the lungs. We have historically relied upon X-rays for the diagnosis of this disease, even though fine particles lodged in the lungs for long periods are almost impossible to detect with X-rays. Thus the illness is not detected until the condition worsens and produces changes in the structure of the lungs. When the condition become detectable with X-rays, it is already too late to transfer the focus in the lungs and complication. In any case, it is essential that we know the quantity of particles in the lungs before illness occurs. However, many years ago, Dr. Cohen et al [2] developed a method to measure the quantity of particles accumulated in the lungs. This method exploits the magnetic properties of the particles and is currently being used in clinics.

Measurement of the magnetic fields of the lung, called magnetopneumography, uses the magnetic characteristic of particles which have accumulated in the lung. The purpose of this research is to use measurement equipment to measure the amount of particles deposited in the lungs. Regular examination of the physical condition of laborers they are within in contaminating workplaces, with a procedure that can detect particulates within safe limits, should prevent pneumoconiosis and new pneumoconiosis cases. In addition, we wanted to learn what correlation cause are particles accumulated in the lung. A number of correlated

parameters are identified, and prevention and control of pneumoconiosis are made possible more reasonably and effectively.

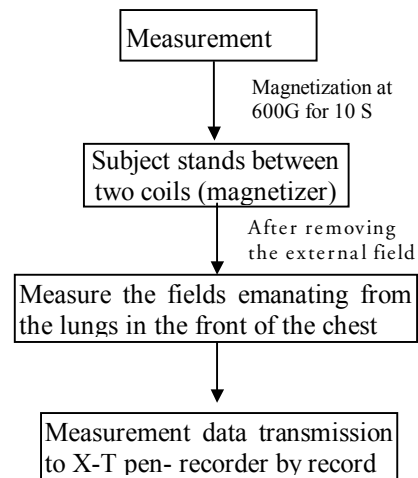


Figure1: *Flow chart of magnetopneumography measurement.*

For the past five years, we have used this equipment to measure, once every two years, the lung magnetic field of the laborers who work in particle contaminated workplaces. As a result, it has been shown that particles have accumulated in many of the laborer's lungs. Here, we report on the relation between the correlation coefficient of the values of particles accumulated in the lungs and on obtained measurement data for in the environment. The correlations of particles which have accumulated in the lungs, business career, smoking and non-smoking, occupational category, etc. are investigated.

2 Methods

The theory of measurement methods for particulate deposited in the lungs depends on the magnetic properties of the particles. If an external, DC(constant) magnetic field is applied to the lungs, the accumulated particles will be magnetized. Residual magnetic fields will continue even after the external field outside the body is removed. By

measuring this, new external fields over the surface of the lungs can be found. Therefore, we can know the amount of particles accumulated in the lungs. In the technique the magnetic properties of the particles, the magnetic fields density of the particles, must be known beforehand.

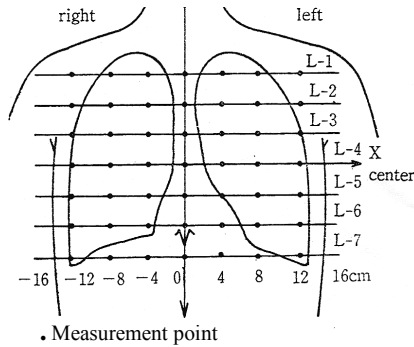


Figure 2: Measurement point plane of front of chest.

Measurements are performed in ideal conditions. A subject is made to stand directly between two magnetic coils. The particles must be magnetized externally, and are subjected to DC magnetic fields of about 600G for 10sec. After magnetization finishes, the subject lies upon a bed, and the magnetometer measures the fields emanating from the lungs at various points. The bed can be moved in two directions, left/right, and forward/backward. As shown in Fig.2, the scan of line 1 starts about 20s later and measurements up to and including line 7 are finished about 2 minutes later. The reference point is set at the intersection of the suprasternal line and the xiphoid process. The horizontal line passing through the reference point is labeled line No. 4. Three horizontal lines were drawn both above and below that line at intervals of 4cm, and these were labeled lines 1, 2, 3, ... 7 starting from the top. The interval between measurement points is 2 cm on the X axis. The flux-gate magnetometer is vertically set up on the bed. The interval between the subject and the probe of the flux-gate magnetometer is adjusted to about 5 mm. The magnetic flux densities measured over the surface of the chest by the flux-gate magnetometer are transmitted to pen-record by record.

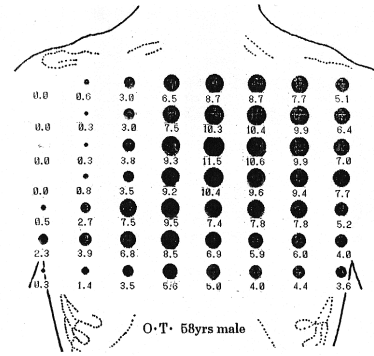


Figure 3: An example of a laborer's magneto-pneumography.

3 Measurement result

As an example, the strength of the magnetic flux density in the surface of the chest is shown using the circle map. The area of the circle map is in direct proportion to the amount of particles accumulated in the lungs as is shown in Fig. 3. Measurements of 227 male subjects were recorded over five years. The subjects averaged 45.9 years old, with range of 19 to 60. The laborers were classified by welding, cutting and others in 1995. In 1997 and 1999, laborers classified were welding and cutting only [3]. This data processing used T- test analysis to give correlation coefficients, and analysis used one dimensional regression.

3.1 Correlation of maximum magnetic flux density with occupation in the past few years

Measurement data was of 150 cases in 1995, 32 cases in 1997 and 45 cases in 1999; the correlation with the occupation career and occupational category and maximum magnetic flux density was analyzed, as shown in table 1 and Fig.4. In each year data, a high correlation was shown between occupation careers and maximum magnetic flux density. There is significant difference in occupational years, i.e. $r(95)=0.99$, $r(97)=0.89$ and $r(99)=0.86$. The highly significant correlation ($P<0.01-0.05$) shows the close relation between the amount of particles accumulated in the lungs and occupation career.

Table1: Measurement data in 1995, 1977 and 1999

1995(150)				1997(32)			1999(45)		
Age range (years)	Ave. occupation career (years)x	Ave maximum magnetic flux density (nT)y	Number of subjects	Ave occupation career (years)x	Ave maximum magnetic flux density (nT)y	Number of subjects	Ave occupation career (years)x	Ave maximum magnetic flux density (nT)y	Number of subjects
<19	2.0	1.1	2				1.4	0.0	3
20<29	4.8	5.0	21	8.3	3.5	3	8.4	1.0	4
30<39	14.5	11.4	15	15.5	7.1	2	17.2	2.1	10
40<49	23.1	20.5	49	26.4	14.3	11	28.8	10.7	5
50<59	22.7	17.9	63	27.4	9.6	16	28.2	5.2	23
$r=0.99$ $P<0.01$ $y=0.82x+0.1$				$r=0.89$ $P<0.05$ $y=0.44x+0.11$			$r=0.86$ $P<0.05$ $y=0.31x-1.4$		

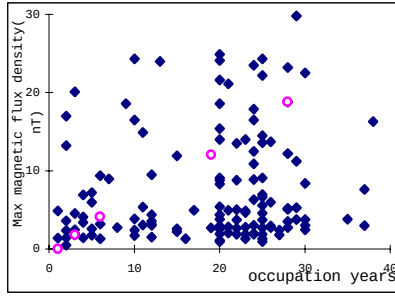


Figure 4: The recurrence straight line showing correlation of occupation with maximum magnetic flux density in 1995.

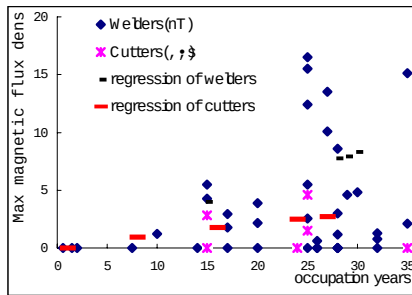


Figure 5: The recurrence straight lines correlation of occupation with max magnetic flux density for welders and cutters in 1999, for welders $r(\text{Welding}) = 0.88$ ($P < 0.05$), But in cutters, $r(\text{cutting}) = 0.41$ ($P > 0.05$).

3.2 Correlation of occupational category with maximum magnetic flux density

Measurement data for welders and cutters in 1999 ($r(\text{welding}) = 0.88$, $p < 0.05$) show a high correlation between occupation career and maximum magnetic flux density. There is significant difference by occupational category. The recurrence straight lines correlations are shown in Fig. 5. For welders, there was shown a high correlation between occupation career and maximum magnetic flux density, and a significant difference in occupational years. But in cutters, ($r = 0.41$, $p > 0.05$), we did not see the correlation of the occupation career and maximum magnetic flux density, and there was no significant difference in occupational years.

3.3 Correlation of occupation with maximum magnetic flux density in smokers and non-smokers

In smoker and non-smoker welders, the correlation of occupational career with maximum magnetic flux density was analyzed from the measurement data of 1999. An extract of subjects' data in the fifties age range is shown in Fig. 6. A high correlation was admitted in both. The cutters show a somewhat

higher correlation with smoker than non-smokers, but no significant difference. In our experiment, we used a device newly developed by the authors: magnetic flux density was measured over the chest surface by a flux-gate magnetometer. An important feature of this device is that it is capable of detecting magnetic fields as weak as 10^{-10}T .

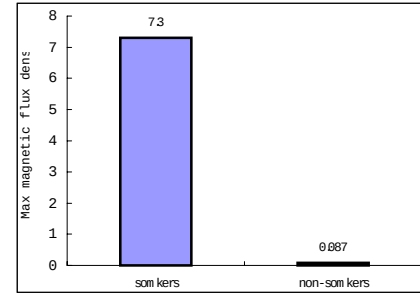


Figure 6: For the welders, the value of magnetic flux density in the lungs of smokers and non-smokers in their fifties, there is significant difference. ($P < 0.05$).

4 Discussion

A Japanese Ministry of Labor publication [1] reports a gradual decrease in particle workplace environments in recent years. However, there has been no decreasing tendency in the number of new cases with the amalgamation syndrome of pneumoconiosis. Needed, then, is a procedure to monitor the rate of particle accumulation in workers at risk that can be used during a physical checkup. At present, there is not a good method for treatment of pneumoconiosis. Pneumoconiosis is regarded as a postnatal disease. The incidence of this disease reduced to 0 should be the target. Therefore, it is necessary to understand what are the relations of particles accumulated in the lungs, we think. Here, we analyzed the characteristics of maximum magnetic flux density in the lungs of the laborers correlated with occupational career, occupational category, smoking and non-smoking, according to the measurement results obtained in the past few years.

4.1 About the correlation with occupation career

Many theses, have reported pneumoconiosis as an occupational disease connected with particle exposure. That the particles accumulated in the lungs are related to long time exposure to particle environments was reported long ago by the Sluis-Cremer research group [4]. In our study from laborers' measurement results for several years,

there is significant correlation between maximum magnetic flux density and occupational career. That is, the quantities of particles accumulated in the lungs are directly proportional to occupational career working in particle environments. To prevent pneumoconiosis, it is suggested that the particle environments of laborers be changed according to the regular examination results of the laborers.

4.2 About the correlation with occupational category

All particles inhaled in a laborer's breath airway are called inhalable dust (inhalation total). The particles invading deep in the lung are called respirable dust (respirable particle). It is admitted that the average diameter of a breathed particle is $0.7\mu\text{m}$, and is given pneumoconiosis of the obstruct to deep in the airway of particles accumulated [5]. From measurement data in 1999 about correlation with the maximum magnetic flux density in welders and cutters, it is pointed out that welders are measured higher than cutters. Moreover, in the same occupational career, same age, where comparing welders and cutters, there is significant higher particle accumulation on the lungs of the former than the latter ($P < 0.05$). As for it, particles which enter through the airway by workers', they can be filtered by dustproof mask when particles are large. When large particles invade the breath airway, thin hair cuticles in the airway exhaust the invading foreign bodies with secretions toward the larynx. On the other hand, particles of diameter $0.5\text{--}15\mu\text{m}$ level float when welding work is done or smoke is made. Therefore, those particles easily invade and accumulate in the lungs of welders, it is thought. It is reported that there is no good method to control generation and the density decentralization of smoke caused by the welding work. We think, consequently, that regular inspection concerning welders is the most important.

4.3 Influence of particles accumulated in lungs for smoking and non-smoking in welders and cutters

The exhaust rate characteristic of particles in a temporary lung modeling non-smokers and smokers was investigated by Dr. Cohen [6]. The result is reported that smokers' exhaust rate of particles is lower than non-smokers. According to our measurement data, maximum magnetic flux density values of the smokers and non-smokers of the same occupation career, age, and occupational category were compared and there is high correlation for welders in the fifties age range (Fig.6). Moreover, the smokers are regarded to accumulate particles

move easily in the lung than non-smokers, in keeping with Cohen's result. There are obstacle qualities in tobacco which reduce airway clearance. Harmful material promoting particle accumulation develops in the lungs, and if particles invade, they are then more easily accumulated. It is reported that airway convulsion is generated by smokers, and it is guessed that frequency dependency increase of the lung compliance and the breath resistance rise are admitted. The functional impairment occurs in both peripheral and central of the airways [7]. Especially, attention is paid nicotine in tobacco is thought that accumulated particles in the smokers' lungs is difficult to remove, because the phagocytotic ability of macrophages has been impaired.

5 Conclusion

We think the magnetopneumography measurement method is useful as one technique for pneumoconiosis prevention. Results of this study show that particles accumulated in the lungs are related to cumulative exposure, occupational category, age and smoking. This method is used not only to investigate the lungs of hospital patients but also to protect laborers in contaminating workplaces from developing pneumoconiosis.

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